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(2)

LACUEVA ARROYO INLET ALBUQUERQUE, NEW MEXICO

by

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The LaCueva Arroyo Inlet collects the runoff in the LaCueva Arroyo basin and merges the flow into the North Diversion Structure, which diverts upland runoff around Albuquerque, NM. Built in the late 1960's, the LaCueva Arroyo Inlet was designed to pass 5,500 cfs. Recent development in the Albuquerque area has generated a proposal to divert 2,000 cfs from a neighboring basin into the LaCueva Arroyo basin, increasing the peak flow to 7,500 cfs. Also due to this development, it has been proposed to remove the existing converging inlet section from the LaCueva Arroyo Inlet and extend the concrete channel several thousand feet upstream. Either of these proposals would change the flow conditions entering the LaCueva Arroyo Inlet.

An existing 1:40-scale model of the North Diversion Structure was extended to include the LaCueva Arroyo Inlet after numerical simulations were unable to reproduce the flow

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conditions at the inlet. Combinations of the as-built conditions and proposed changes were tested in the physical model to determine the flow conditions for the as-built design at design flows and the changes in the flow conditions due to the proposed changes.

In the as-built structure with the design flow in the LaCueva Arroyo Inlet, flow intermittently overtopped the left berm of the North Diversion Structure due to a standing wave that formed in the junction of the LaCueva Arroyo Inlet channel and the North Diversion Structure. A vertical wall 120 ft long and 3 ft high located on top of the left berm was sufficient to keep the flow in the North Diversion Structure. The extension of the LaCueva Arroyo Inlet channel had no noticeable effect on the flow conditions due to the steeper slope in the existing portion of the channel. The addition of 2,000 cfs caused the flow to consistently overtop the left berm of the North Diversion Structure at approximately the same location. However, the same vertical wall was adequate to contain the flow in the North Diversion Structure.

PREFACE

The model investigation reported herein was authorized by the Headquarters, US Army Corps of Engineers, on 28 August 1986 at the request of the US Army Engineer District, Albuquerque (SWA). The studies were conducted by personnel of the Hydraulics Laboratory (HL), US Army Engineer Waterways Experiment Station (WES), during the period September 1986 to June 1987. All studies were conducted under the direction of Messrs. F. A. Herrmann, Jr., Chief, HL, and G. A. Pickering, Chief of the Hydraulic Structures Division. Tests were conducted by Messrs. C. H. Tate, Jr. and J. Cessna, Locks and Conduits Branch, under the supervision of Mr. J. F. George, Chief of the Locks and Conduits Branch. This report was prepared by Mr. Tate.

Acting Commander and Director of WES during preparation of this report was LTC Jack R. Stephens, EN. Technical Director was Dr. Robert W. Whalin.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measure used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831658	cubic metres
feet	0.3048	metres

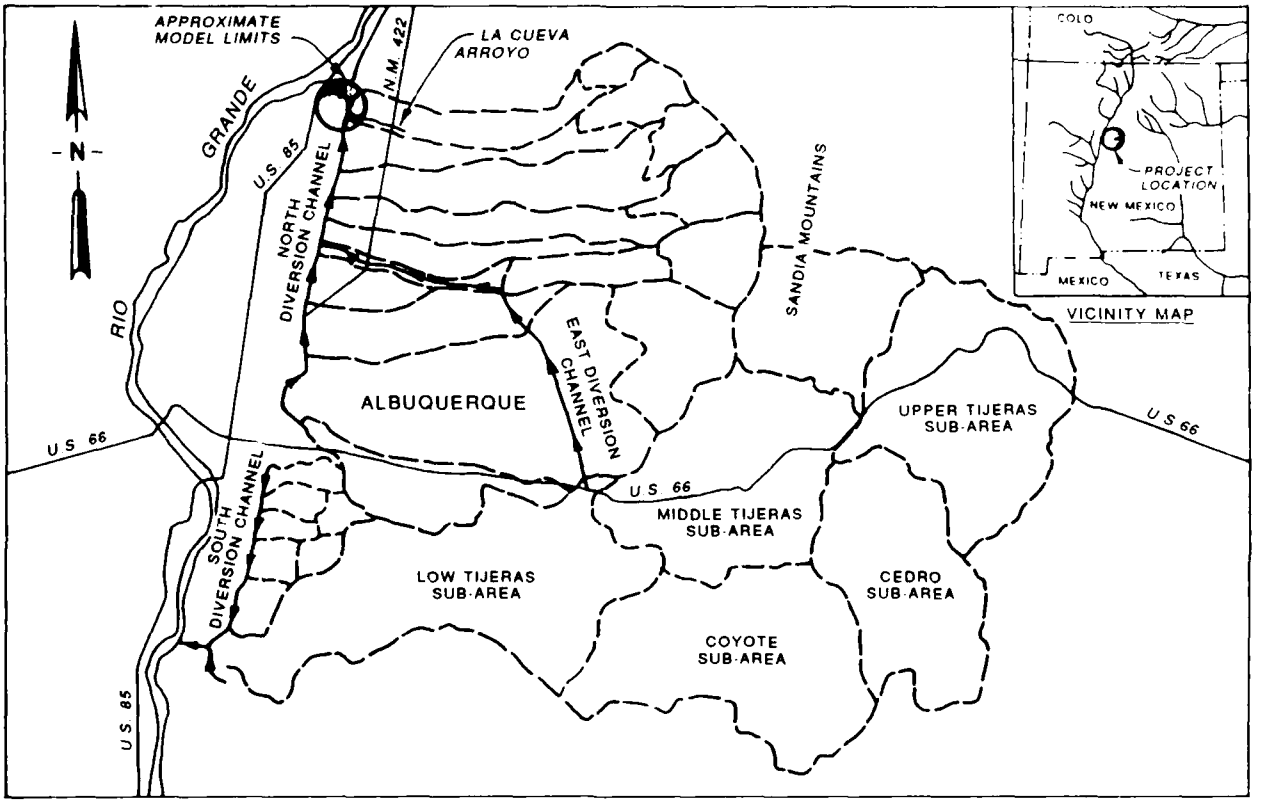

Figure 1. Location map

LaCUEVA ARROYO INLET, ALBUQUERQUE, NEW MEXICO

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The LaCueva Arroyo Inlet is one of several inlets to the North Diversion Structure, north of Albuquerque, New Mexico (Figure 1). Runoff from the mesa and western slopes of the Sandia Mountains drains through the arroyos and is intercepted by the North Diversion Structure which directs the flow around Albuquerque in a supercritical flow concrete channel. The LaCueva Arroyo Inlet was constructed with a converging entrance and a curved concrete channel to merge the inflow from the arroyo with the flow in the North Diversion Structure (Plate 1).

2. The LaCueva Arroyo Inlet was designed for a maximum flow of 5,500 cfs with a concurrent flow of 31,000 cfs in the main channel. Recent development in the LaCueva Arroyo and Camino Arroyo basins has prompted a proposal to divert 2,000 cfs from the Camino Arroyo basin to the LaCueva Arroyo basin which would increase the peak flow in the LaCueva Arroyo Inlet to 7,500 cfs. Included in the proposal is the extension of the concrete channel portion of the LaCueva Arroyo Inlet well up into the drainage basin, eliminating the existing converging entrance to the inlet.

3. Within the model limits, the North Diversion Structure is a concrete trapezoidal channel with a 25-ft base width and 1V:2H side slopes (Plate 1). The LaCueva Arroyo Inlet converges through riprap-protected abutments to a converging concrete section into a 520.87-ft radius curve trapezoidal channel with a 15-ft base width and 1V:2H side slopes. A tangent section merges with the North Diversion Structure at a 20-degree angle well above the invert of the main channel.

Purpose of Model Investigation

4. Either of the proposed changes, the diversion of 2,000 cfs into the LaCueva Arroyo basin or the extension of the concrete LaCueva Arroyo channel

upstream into the basin, would change the flow conditions entering the curve at the existing inlet. Numerical simulations were unable to reproduce the flow conditions at the inlet. Accordingly, the physical model study was conducted to determine the flow conditions at the inlet for any combination of the proposed changes and to determine what modifications, if any, would be necessary to provide acceptable flow conditions within the system.

PART II: THE MODEL

Description

5. An existing 1:40-scale model of the outlet portion of the North Diversion Structure* was extended upstream to Sta. 100+50. The LaCueva Arroyo Inlet was reproduced from the intersection with the main channel at Sta. 94+00 (Photo 1) to Sta. 104+00A (Photo 2) which is upstream of the converging section and in the ponded area of the inflow. The model berms were constructed higher than the prototype berms to prevent spillage from the model. Lines on the side slopes, shown in Photo 1, approximated the top of the prototype berms. Plastic-coated plywood was used to construct the straight portions of the model with concrete used to mold the curved sections in the model. Sand and scaled rock were used to construct the riprap-protected converging approach to the LaCueva Arroyo Inlet.

6. The coefficient of roughness of the model surface of the channel had previously been determined to be approximately 0.009 (Manning's n). Basing similitude on the Froudian relation, this n value would be equivalent to a prototype n of 0.017. The n value used in the design and analysis of the prototype channel was 0.013; therefore, a supplementary slope was added to the model to correct for the difference in the n values of the model and prototype.

7. Flow to this model was supplied through a circulating system. Discharges were measured with differential pressure manometers and controlled with manual gate valves.

8. Flow in the main channel was supercritical and the flow depth entering the model was set by regulating the inflow velocity. Flow entering the main channel was set to normal depth due to the long, relatively uniform channel section upstream of the LaCueva Arroyo Inlet junction in the prototype.

9. Point gages were used to measure water-surface elevations throughout the model. Flow conditions were observed for the different designs tested,

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* Charles H. Tate, Jr. 1987 (May). "North Diversion Structure, Albuquerque, New Mexico; Hydraulic Model Investigation," Technical Report H-87-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

with flow conditions in the original and recommended designs being recorded photographically.

Scale Relations

10. The accepted equations of hydraulic similitude, based on the Froudian criteria, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. These general relations were used for the transference of model data to prototype equivalents:

Characteristic	Dimension*	Model:Prototype
Length	L_r	1:40
Discharge	$Q_r = L_r^{5/2}$	1:10,119
Roughness coefficient	$N_r = L_r^{1/6}$	1:1.849

* Dimensions are in terms of length.

Model measurements of discharge, water-surface elevations, and velocities can be transferred quantitatively to prototype equivalents by means of the scale relations. Experimental data also indicate that the model-to-prototype scale ratio is valid for scaling stone in the sizes used in this investigation.

PART III: TESTS AND RESULTS

Test Conditions

11. The existing LaCueva Arroyo Inlet was designed and built based on a 5,500-cfs maximum flow in the LaCueva Arroyo Inlet with a concurrent flow of 31,000 cfs in the North Diversion Structure. At the maximum flow of 40,000 cfs in the North Diversion Structure, the LaCueva Arroyo Inlet would convey 2,000 cfs. Due to changes within the drainage basin, the Albuquerque Metropolitan Arroyo Flood Control Authority desired to increase the maximum flow in the LaCueva Arroyo Inlet to 7,500 cfs without changing the other flows. The testing program was set up to determine the flow conditions at the junction for the as-built design and for the proposed channel extension with the following flow combinations:

LaCueva Arroyo Inlet	North Diversion Structure
2,000 cfs	40,000 cfs
5,500 cfs	31,000 cfs
7,500 cfs	31,000 cfs

As-Built Design

12. Water-surface profiles and photographs were used to document the flow conditions at the junction. For the 2,000-cfs flow in the LaCueva Arroyo Inlet, the flow remained within the channel at all locations (Photos 3 and 4 and Plate 2). Intermittent overtopping of the left berm (looking downstream) of the North Diversion Structure occurred at approximately Sta 94+60 for the 5,500-cfs flow in the LaCueva Arroyo Inlet as shown in Photos 5 and 6 and in Plate 3. Flow consistently overtopped the left berm at approximately the same location at the 7,500-cfs flow in the LaCueva Arroyo Inlet (Photos 7 and 8 and Plate 4). A 3-ft-high vertical wall located on top of the existing left channel berm between Sta 94+00 and Sta 95+20 was adequate to contain all flow conditions observed in the North Diversion Structure for the as-built design. Flow conditions did not change significantly with this modification as shown in Photos 9 and 10. Runup on the right side of the North Diversion Structure at approximately Sta 94+25 greatly reduced the freeboard at this location.

Proposed Channel Extension

13. The proposed extension of the concrete LaCueva Arroyo Inlet channel was reproduced by removing the converging abutments and concrete channel upstream of Sta 101+63.67A and installing 400 ft of straight trapezoidal channel (Photo 11). Normal depth based on a Manning's n of 0.013 was set at Sta 103+00 for the observed flows. Flow conditions at the junction with this design were similar to the flow conditions observed for the as-built design with overtopping of the left berm of the North Diversion Structure around Sta 94+60 (Photos 12 and 13 and Plates 5-7). The same modification designed for the as-built condition, which involved the installation of a 3-ft-high vertical wall, was found to be acceptable for the proposed LaCueva Arroyo Inlet extension as shown in Photos 14 and 15.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

14. Tests to ascertain the ability of the North Diversion Structure and the LaCueva Arroyo Inlet to convey the design flows and the additional 2,000 cfs indicated that the structures, with one modification, would perform satisfactorily. Installation of a 3-ft-high wall on the left berm between Sta. 94+00 and Sta. 95+20 in the main channel would contain the flow that runs up the left berm due to the standing wave at the channel junction. The proposed extension of the concrete LaCueua Arroyo channel had no discernable affect on the flow conditions at the channel junction. This appears to be due to the steep slope in the curved portion of the LaCueva Arroyo Inlet.

15. Runup on the right side of the North Diversion Structure at approximately Sta 94+25 greatly reduced the freeboard at this location. Though not observed, intermittent overtopping is possible at the maximum discharge from the LaCueva Arroyo Inlet. Due to the interior drainage channel paralleling the North Diversion Structure any overtopping flow would be collected safely and should not cause problems. Based on the flow combinations observed, modifications are not required at this location.

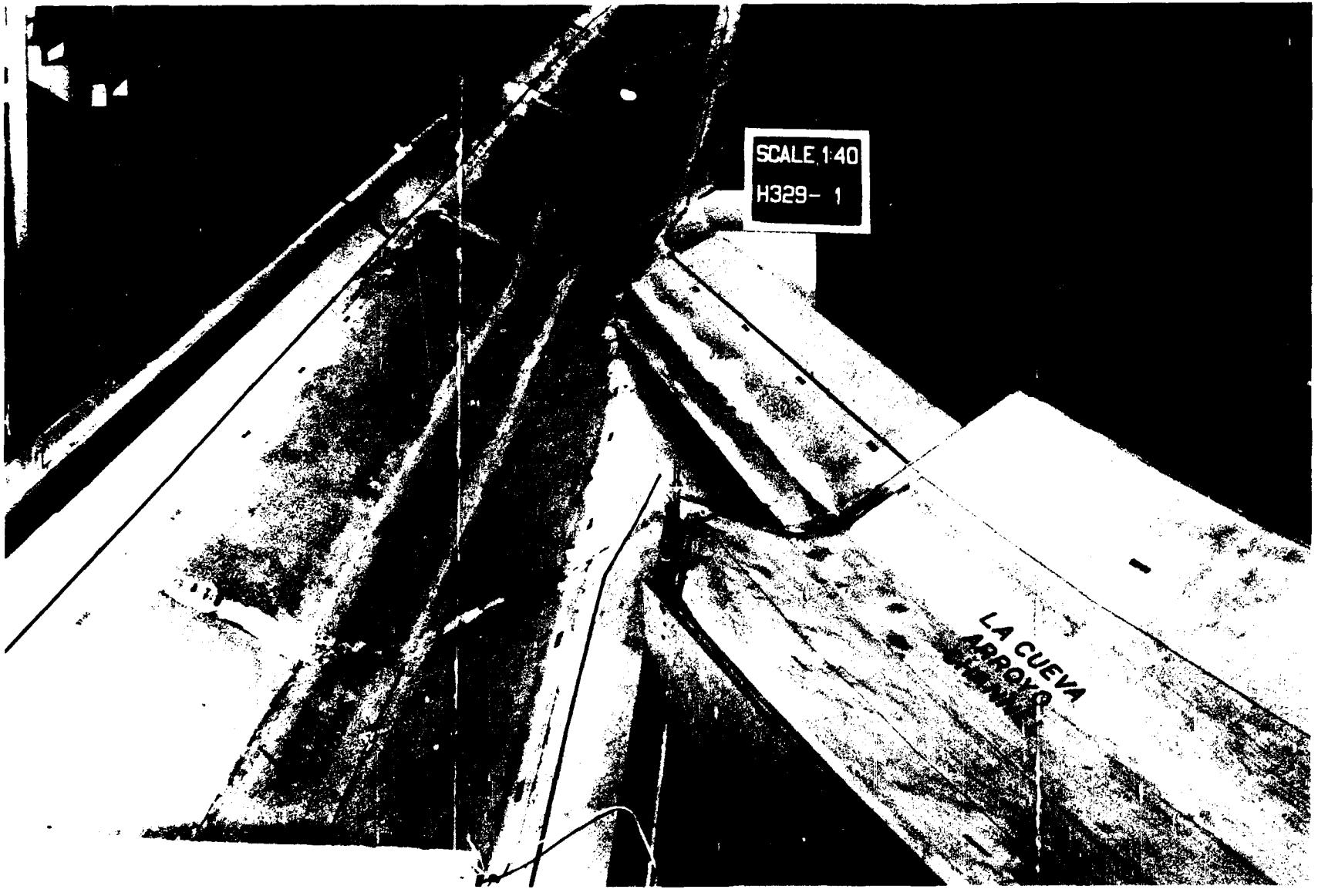


Photo 1. Junction of the North Diversion Structure and the LaCueva Arroyo Channel, as-built design

Photo 2. As-built entrance to the LaCueva Arroyo Channel

Photo 3. As-built design, LaCueva Arroyo Channel flow 2,000 cfs, North Diversion Structure flow 40,000 cfs

Photo 4. As-built design, LaCueva Arroyo Channel flow 2,000 cfs, North Diversion Structure flow 40,000 cfs

Photo 5. As-built design, LaCueva Arroyo Channel flow 5,500 cfs, North Diversion Structure flow 31,000 cfs

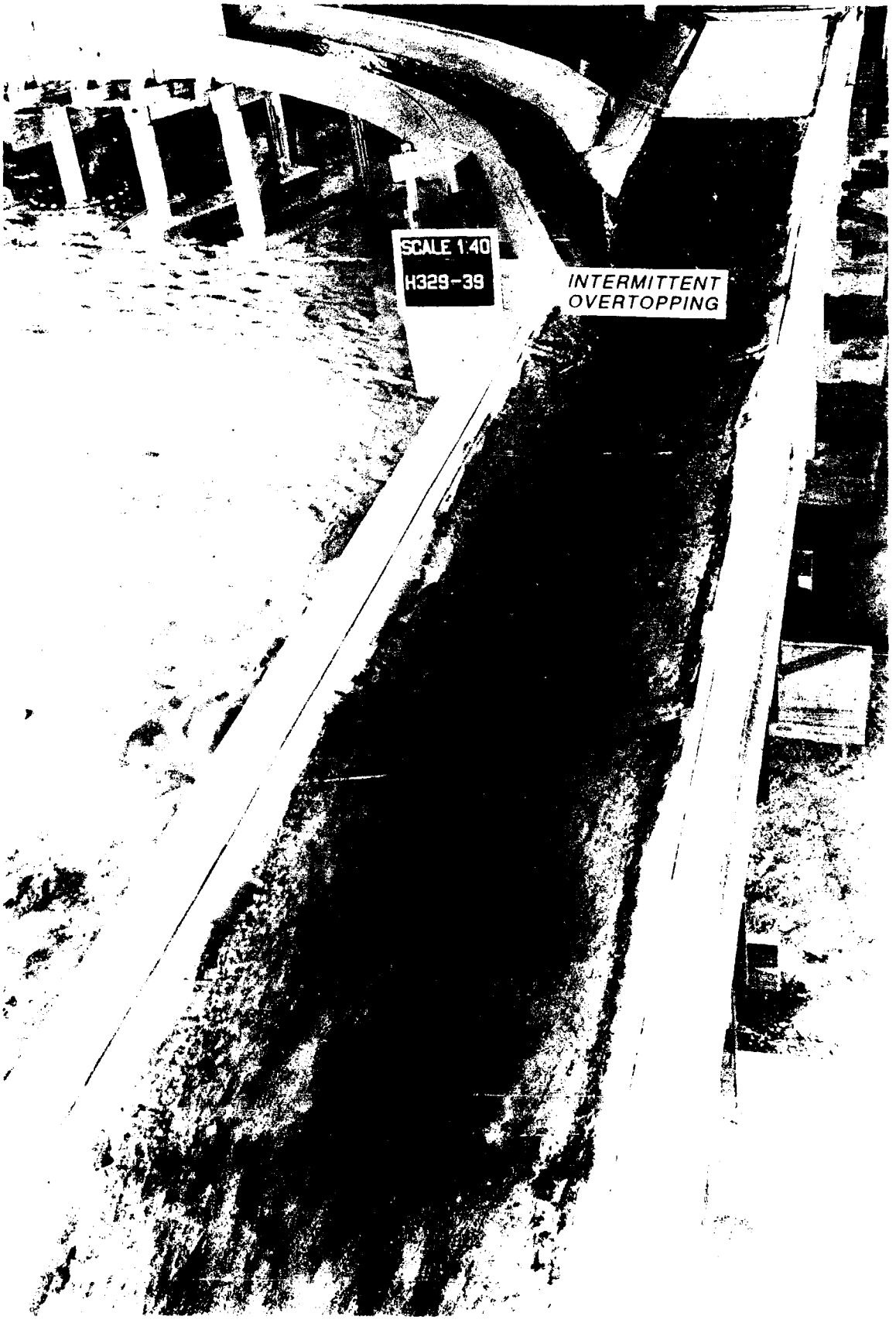


Photo 6. As-built design, LaCueva Arroyo Channel flow 5,500 cfs, North Diversion Structure flow 31,000 cfs

Photo 7. As-built design, LaCueva Arroyo Channel flow 7,500 cfs, North Diversion Structure flow 31,000 cfs

Photo 8. As-built design, LaCueva Arroyo Channel flow 7,500 cfs, North Diversion Structure flow 31,000 cfs

Photo 9. As-built design with additional wall height, LaCueva Arroyo Channel flow 5,500 cfs, North Diversion Structure flow 31,000 cfs

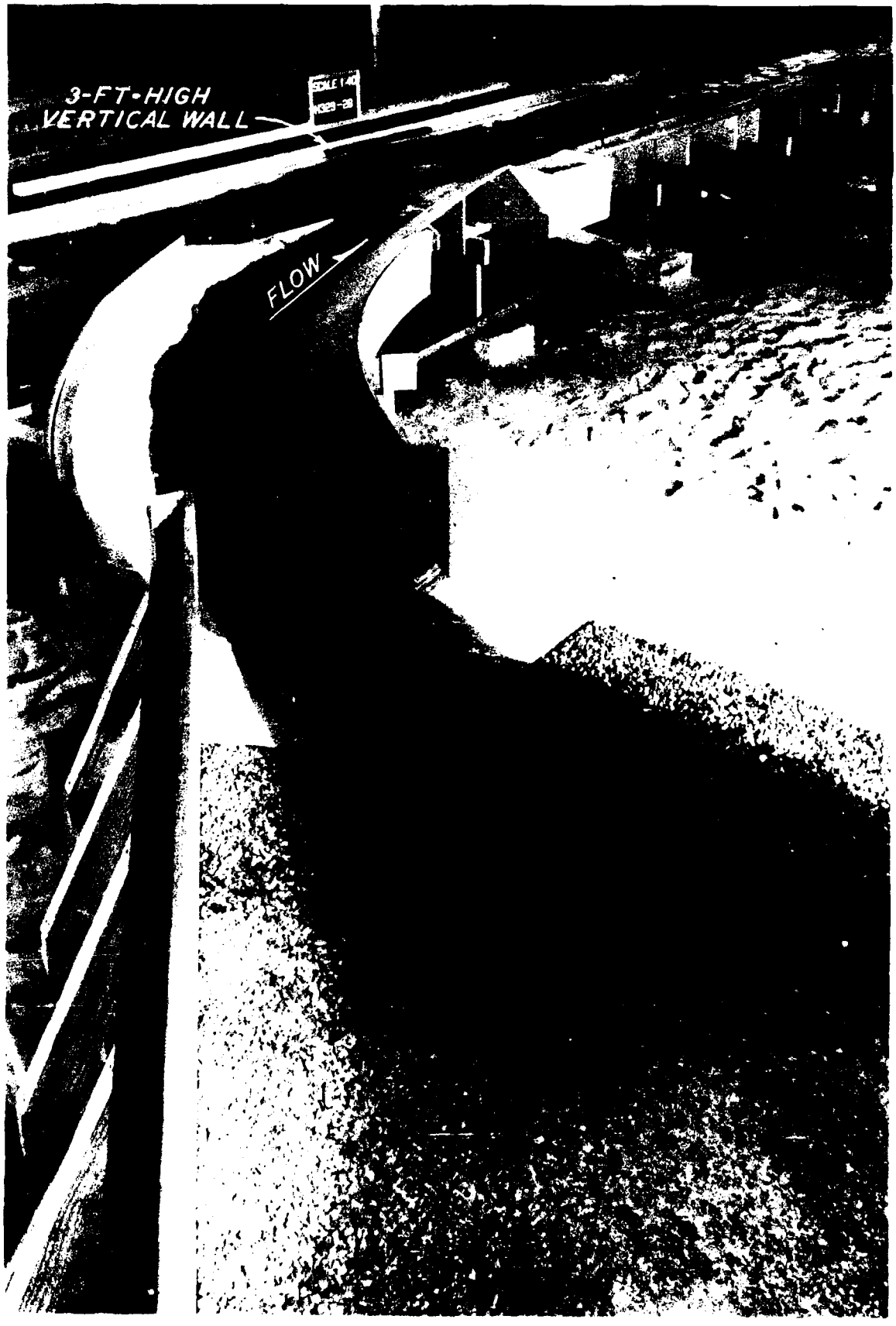


Photo 10. As-built design with additional wall height, LaCueva Arroyo Channel flow 7,500 cfs, North Diversion Structure flow 31,000 cfs

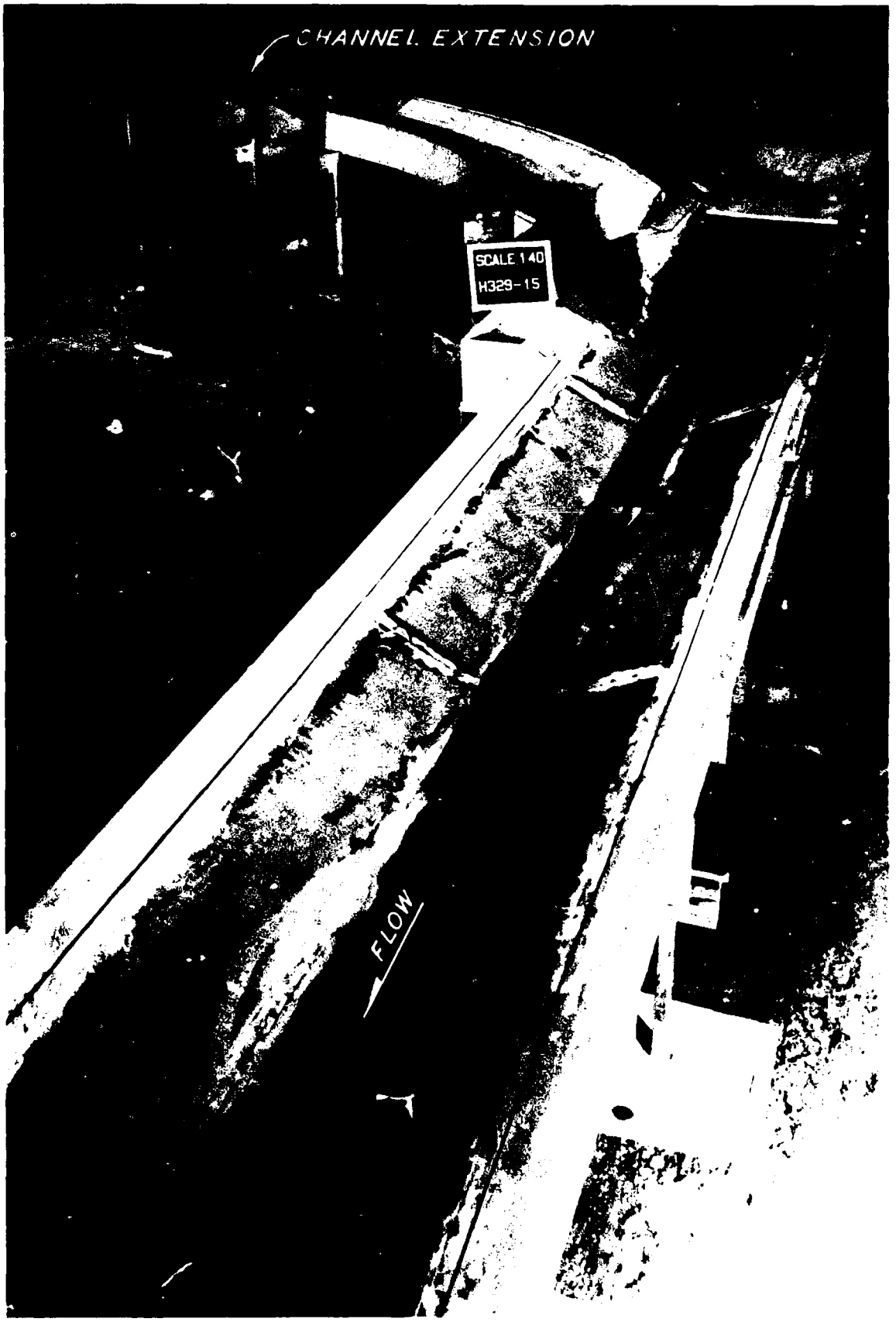


Photo 11. Junction of the North Diversion Structure and the LaCueva Arroyo Channel with the proposed channel extension

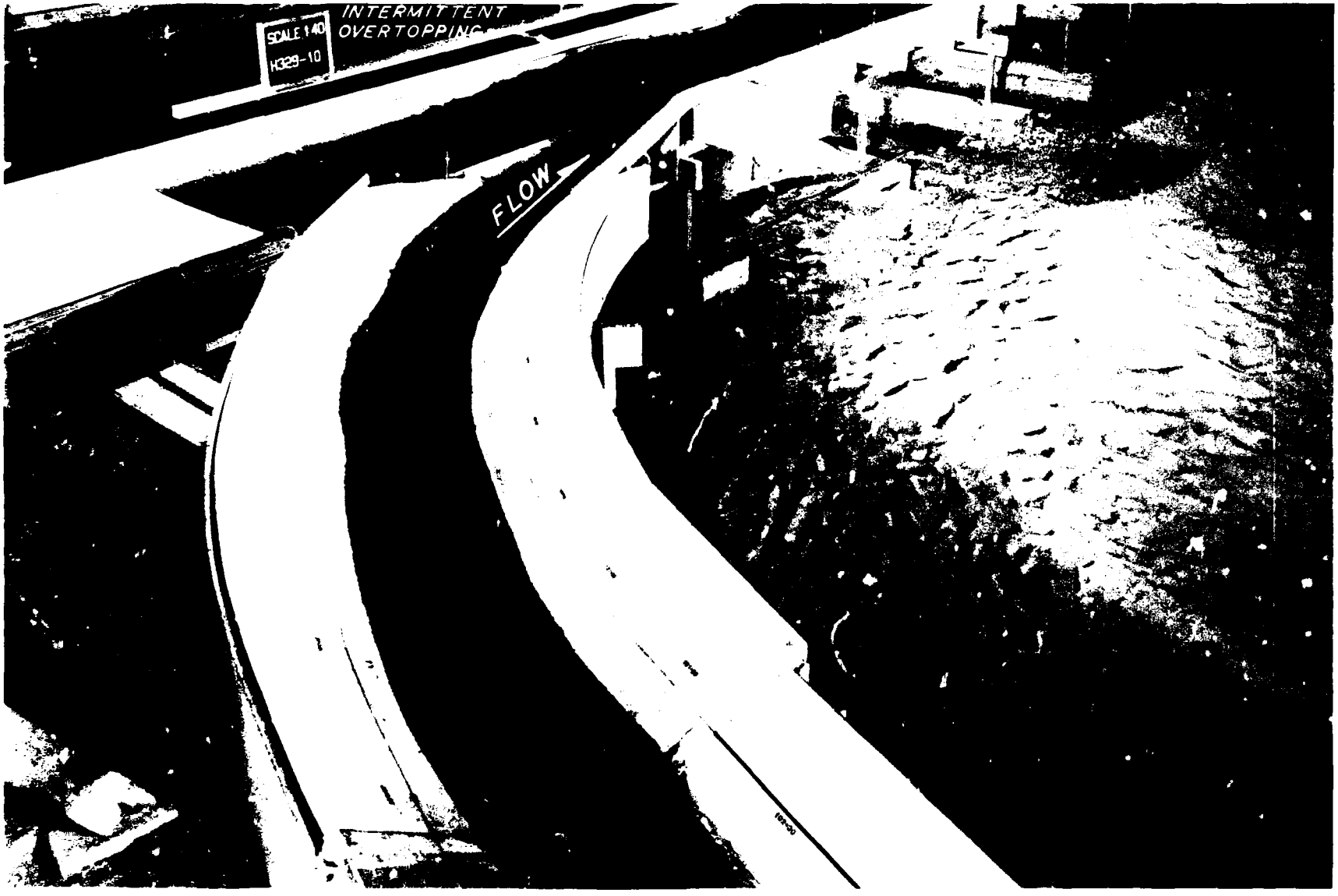


Photo 12. Proposed LaCueva Arroyo Channel extension design, LaCueva Arroyo Channel flow 5,500 cfs, North Diversion Structure flow 31,000 cfs

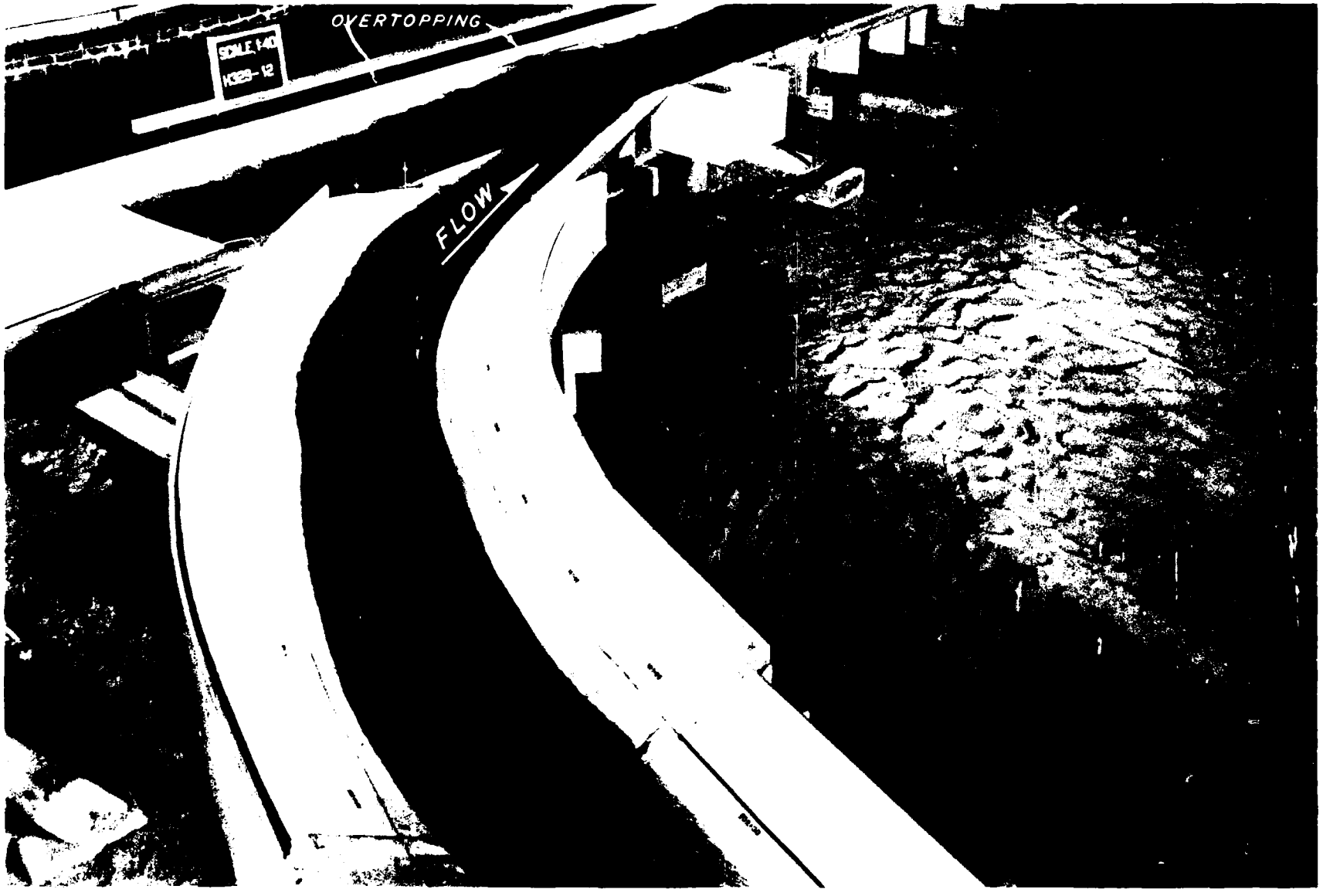


Photo 13. Proposed LaCueva Arroyo Channel extension design, LaCueva Arroyo Channel flow 7,500 cfs, North Diversion Structure flow 31,000 cfs

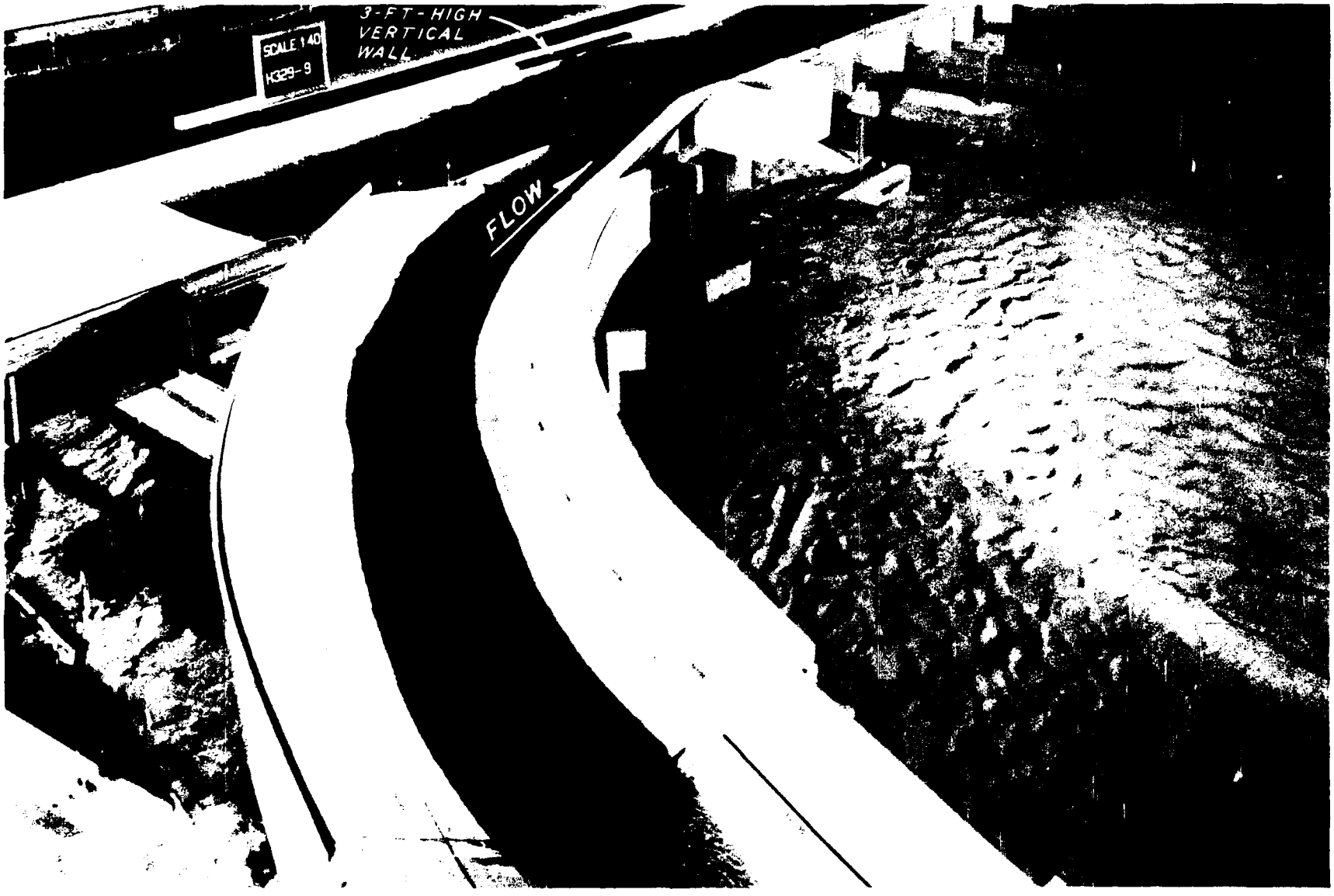


Photo 14. Proposed LaCueva Arroyo Channel extension design with additional wall height, LaCueva Arroyo Channel flow 5,500 cfs, North Diversion Structure flow 31,000 cfs

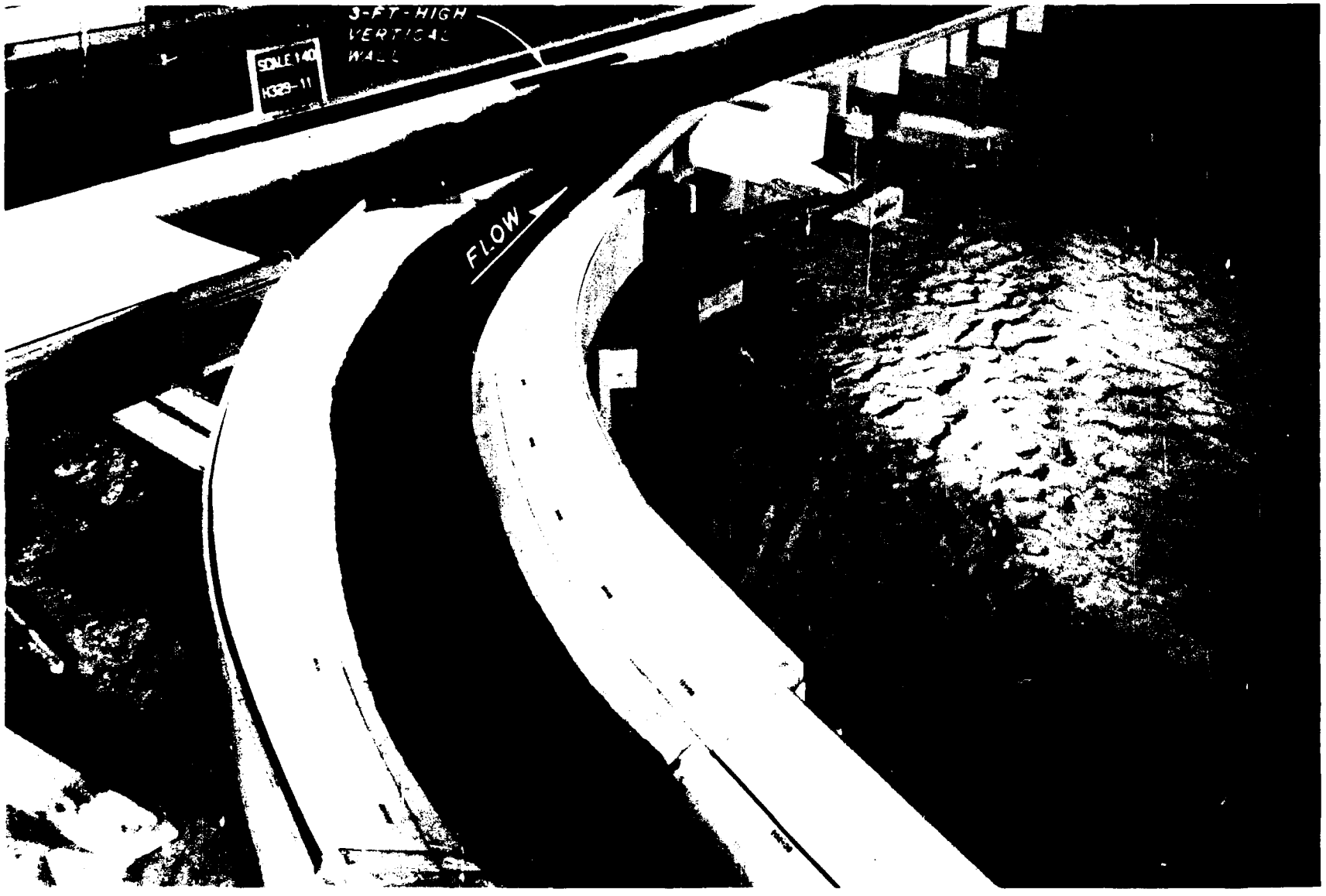


Photo 15. Proposed LaCueva Arroyo Channel extension design with additional wall height, LaCueva Arroyo Channel flow 7,500 cfs, North Diversion Structure flow 31,000 cfs

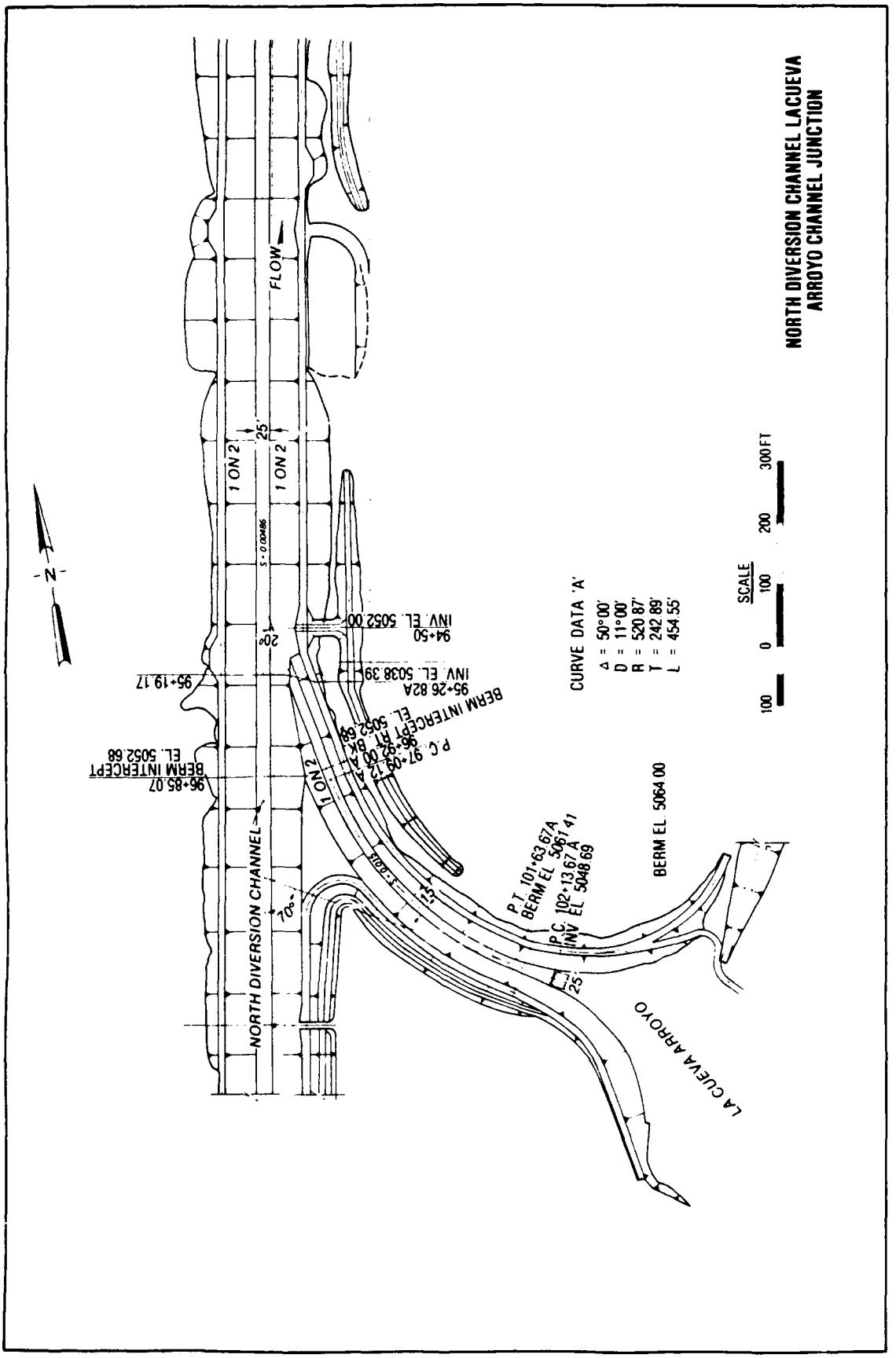
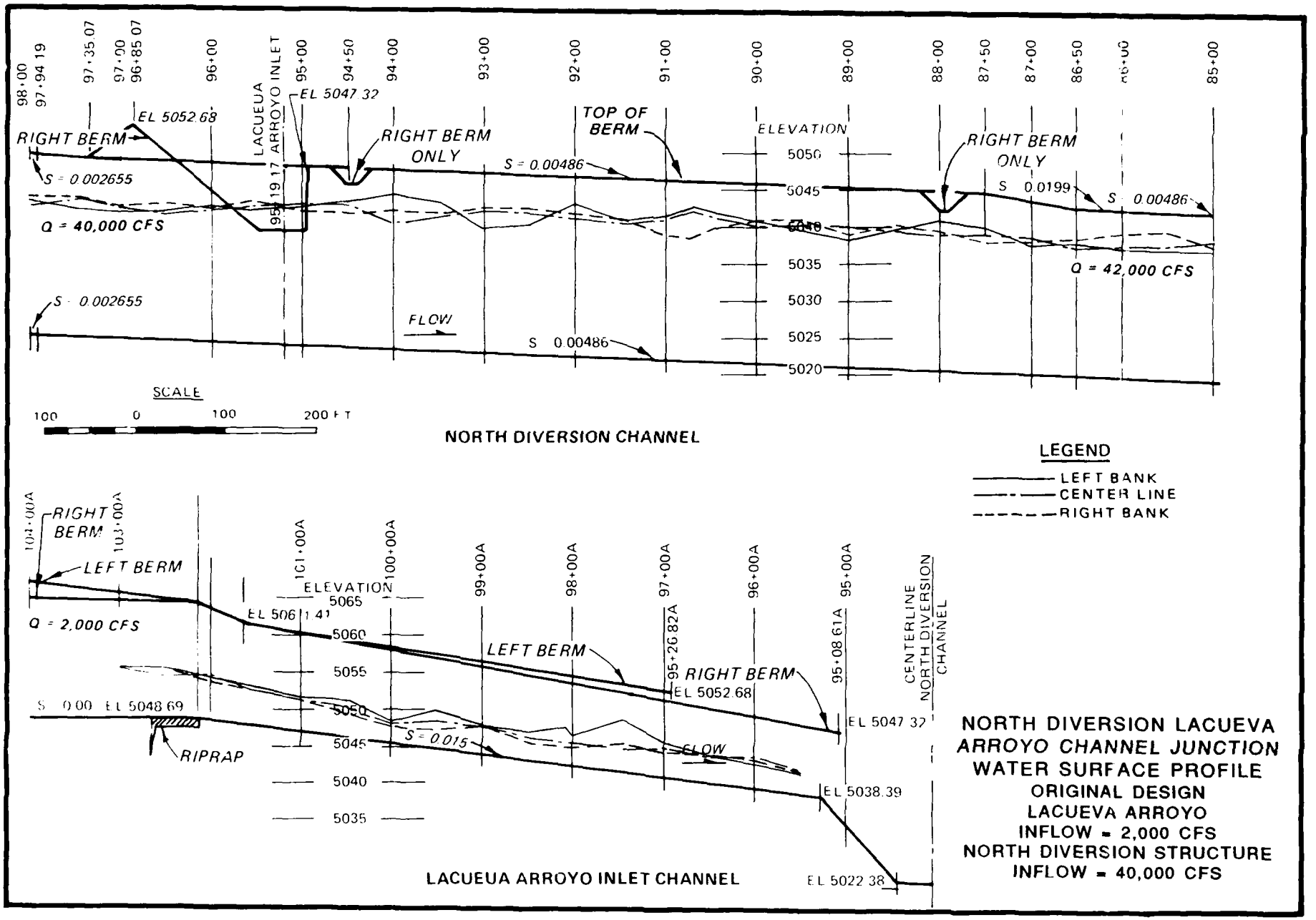
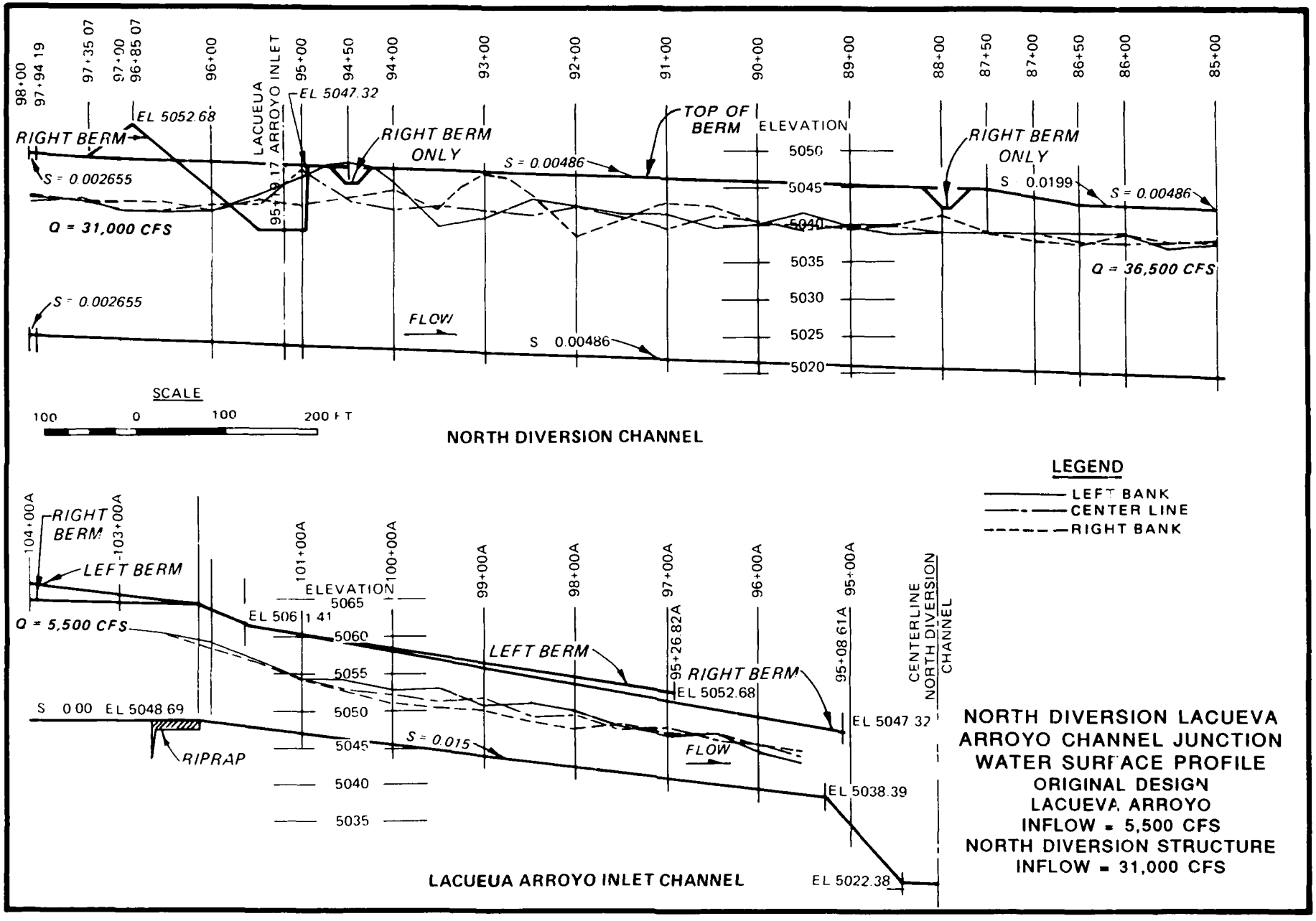

NORTH DIVERSION CHANNEL LACUEVA
ARROYO CHANNEL JUNCTION
FLOW
1 ON 2
25'
20'
NORTH DIVERSION CHANNEL
70°
LA CUEVA ARROYO
BERM EL. 5064.00
CURVE DATA 'A'
Δ = 50°00'
D = 11°00'
R = 520.87'
T = 242.89'
L = 454.55'
SCALE
100 0 100 200 300 FT
P.T. 101+63.67A
BERM EL. 5061.41
P.C. 102+13.67A
INV EL. 5048.69
P.C. 97+09.12A
96+92.00 BK
INV EL. 5052.68
BERM INTERCEPT
EL. 5052.68
96+85.07
95+19.17
INV EL. 5038.39
95+26.82A
BERM INTERCEPT
EL. 5052.00
94+50

PLATE 1

PLATE 2



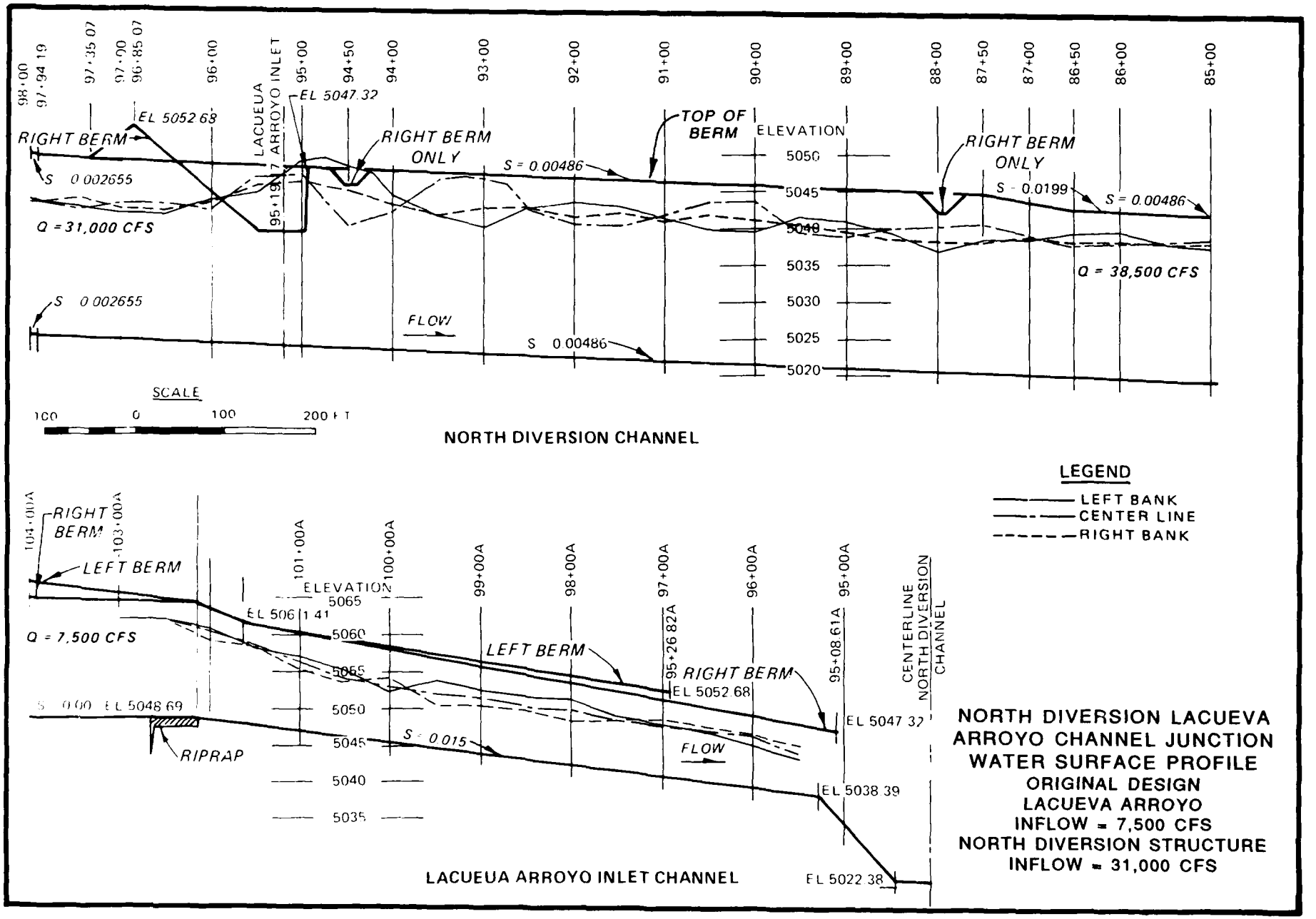
NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
ORIGINAL DESIGN
LACUEVA ARROYO
INFLOW = 2,000 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 40,000 CFS



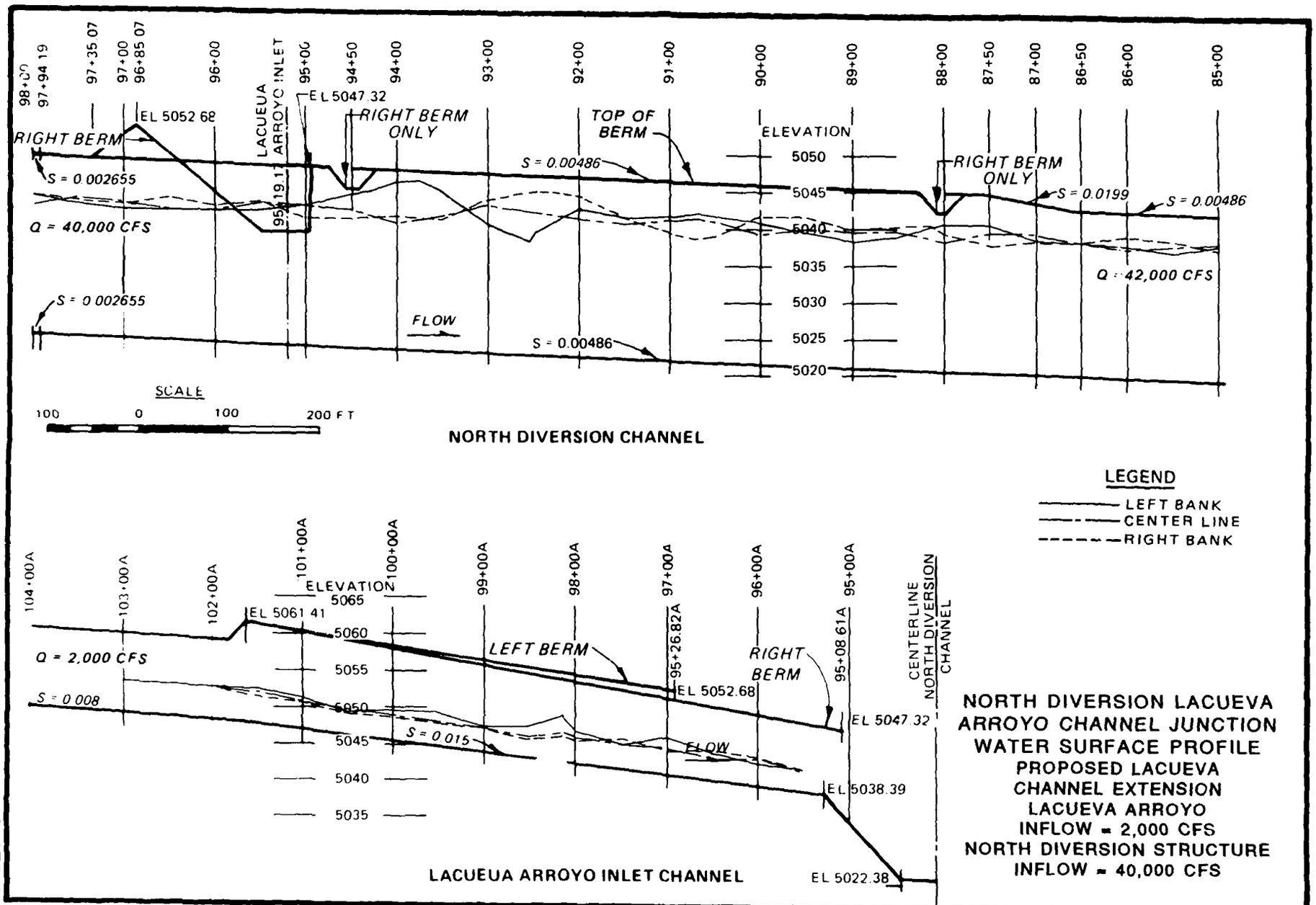
NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
ORIGINAL DESIGN
LACUEVA ARROYO
INFLOW = 5,500 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 31,000 CFS

PLATE 3

PLATE 4



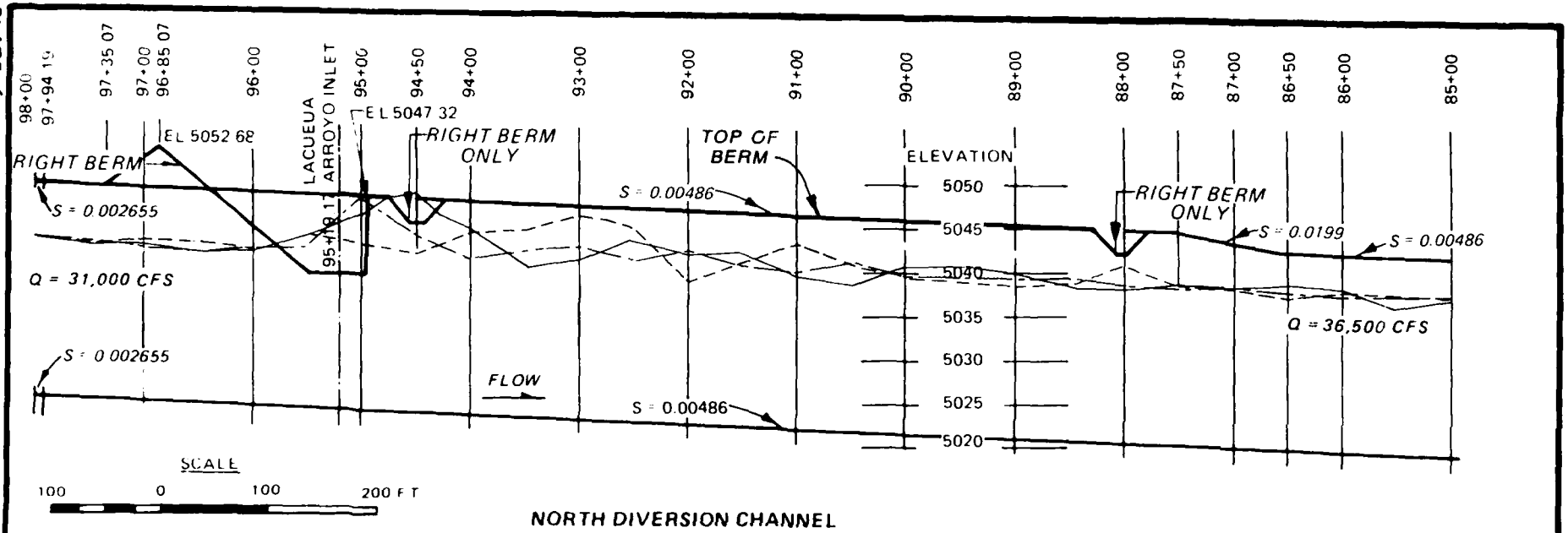
NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
ORIGINAL DESIGN
LACUEVA ARROYO
INFLOW = 7,500 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 31,000 CFS

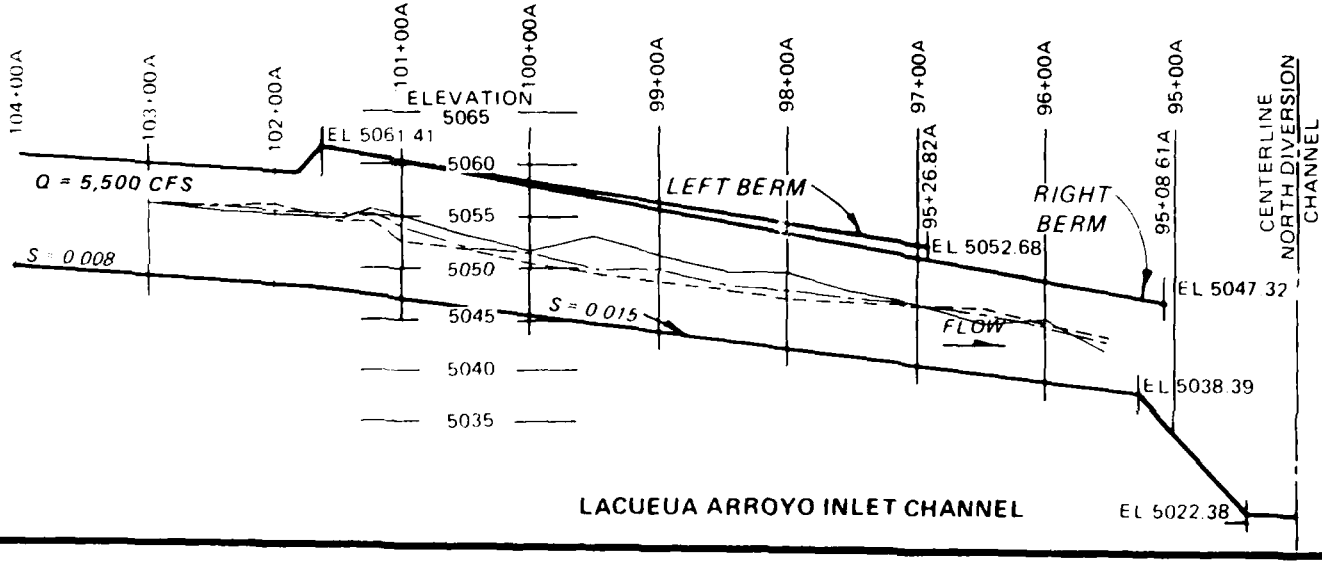


NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
PROPOSED LACUEVA CHANNEL EXTENSION
LACUEVA ARROYO
INFLOW = 2,000 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 40,000 CFS

PLATE 5

PLATE 6

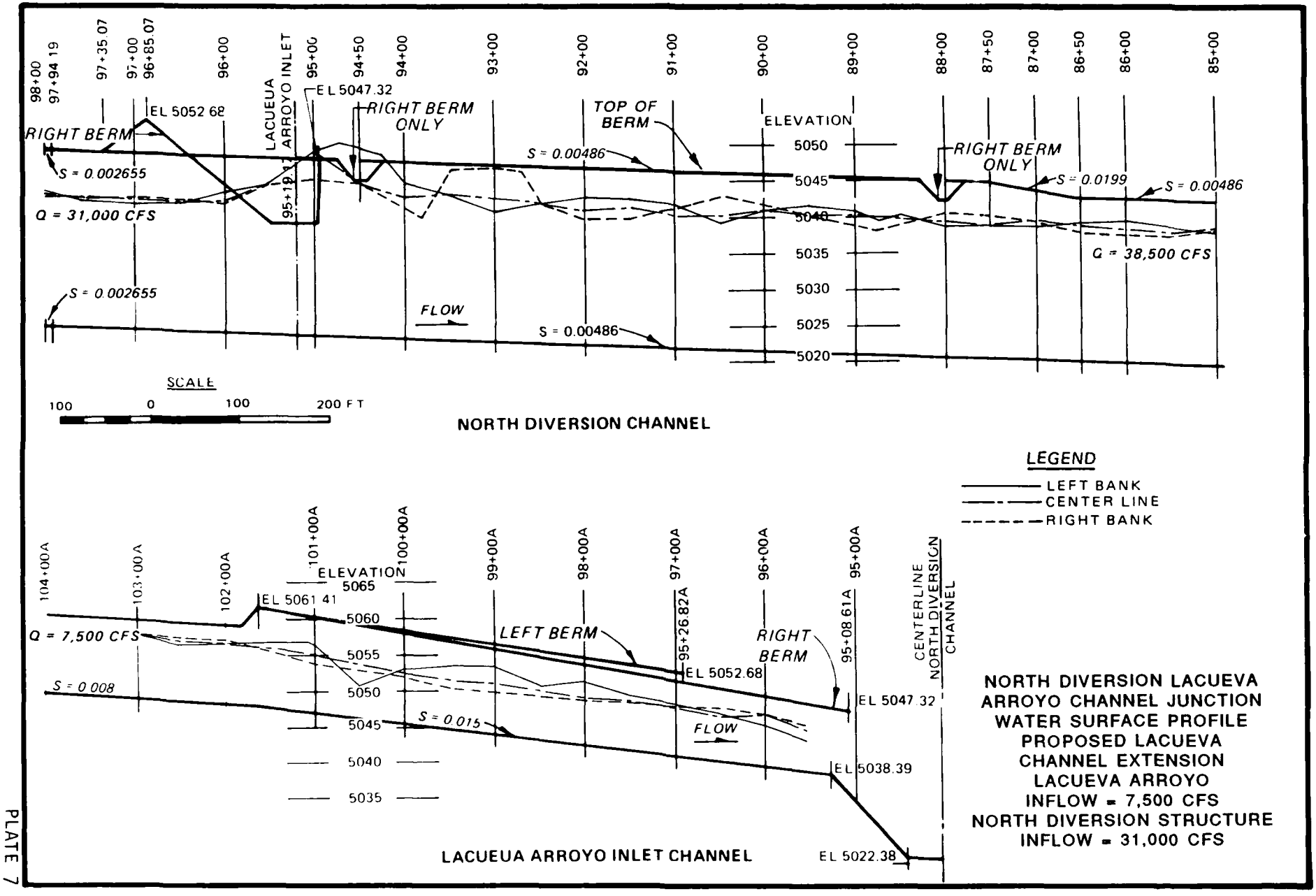




LEGEND

LEFT BANK
CENTER LINE
RIGHT BANK

NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
PROPOSED LACUEVA CHANNEL EXTENSION
LACUEVA ARROYO
INFLOW = 5,500 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 31,000 CFS



NORTH DIVERSION LACUEVA ARROYO CHANNEL JUNCTION WATER SURFACE PROFILE
PROPOSED LACUEVA CHANNEL EXTENSION
LACUEVA ARROYO
INFLOW = 7,500 CFS
NORTH DIVERSION STRUCTURE
INFLOW = 31,000 CFS

PLATE 7